Different Management Operation for Controlling a Destructive Pest Fall Armyworm~~armyworm~~ (*S~~s~~podpetera frugiperda*): A Review

Abstract:
The fastest-growing pests natively belong to southern America and are most devasting in nature known as fall armyworms (***Spodptera frugiperda***). The first incidence was observed in 2016 and in the current time, it became a most destructive and serious pest for the whole world. This is a polyphagous pest. It causes havoc damage to crops that's why it is called a fall armyworm, by skeletonising leaves and boring of stem ~~feed~~ feeds on leaves of maize. By the cultural methods the reduction in yield is sustained up to 53% in this method there is a major role played by the push and pull method. Neem powder and other plant species are also played a vital role by showing the ~~toxicity~~ toxic nature against this pest. By the *Trichogramma parasitizing faw eggs*, the reduction in the fall armyworm population is shown as 80-87%, and with the help of Chlorpyriphos application reduction in the total population of fall armyworm is observed 87-90%. Some Bio-Insecticides are also played a vital role in the control of this pest. This all practices is considered in the integrated pest management of the fall armyworm.

Key word: *Fall armyworm, devasting, integrated pest management, Strategies.*

1. Introduction:

I~~I~~n the whole world, cereals play a vital role in every person's diet. In the production of cereals, there were lots of problems have seen by the farmers so in that problem a major problem of pest attack on crops. On queen of cereals i.e., maize (***Zea mays)*** major damage is seen on leaves and leave whorls that are caused by a pest of the cereal's crops (FAO, 2017and CABI, 2018). This pest ~~seemed at~~appeared worldwide in maize, sorghum, rice, wheat, and more crops belonging to the Poaceae family (Abrahams *et al*, 2018). Pest belongs to the Noctuidae family and jumps in the Lepidoptera order known as fall armyworm ***(Spodoptera frugiperda)*** J.E. SMITH, 1797 (Goergen (a) *et al*, 2016). Fall armyworm is a highly destructive and polyphagous pest scientifically known as ***Spodoptera frugiperda*** (Baudron *et al*, 2019). Natively belongs to tropical and subtropical America (Goregen (b) *et al*, 2018). Fall armyworm feeds on leaves, wore the stems, and damage reproductive parts of the crop (Tefera *et al*, 2019). When fall armyworms were discovered in America, they became a major pest of maize in South and North America.~~When fall armyworms were found in America so it was a major pest of maize in South and North America~~ (Luginbill, 1928). Now it is a major pest of 353 host plants in 40 countries (Kansiime *et al*, 2019). Its damaging strategy was very different at the larvae stage it feeds on leaves and bores in stems and reproductive parts although the last ~~instars~~ instar larva can cut through the base of seeding maize ~~thats~~ that's why the whole plant will die.

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Newly emerged larvae (1hrs to 2hrs old) feed in the blossom and bore the stems internally of the maize (Ali *et al*, 1990). Major identifying symptoms of the damage on the crop are skeletonising and defoliation of leaves and boring stems. This pest marches like to military and causes havoc damage on the crops that's why this pest is known as the fall armyworm (FAO, 2019 and CABI, 2019). In Africa, this pest caused a 6.1-million-dollar Loss to the African ~~peoples~~ people ~~at~~ because the no measures and methods to control it (CABI, 2017a). Due to the high consumption of cereals like rice, and maize in smallholder diets, fall armyworm could have a substantial negative impact on food security (Harrison *et al*, 2019). This is a sporadic pest and migrated worldwide and its adult can fly up to 100km in a single night (Johnson, 1987). Fall armyworm does not have any ~~diapose~~diapause in its life cycle it is capable of overwintering in warmer climates. The female laid egg masses of hundreds of eggs, usually, on the underside of the leaves, hatching all the first ~~instars~~ instar larvae show phototaxis, moving to the upper part of the plant and dispersing from it by the ballooning on silk threads (Van Huis, 1981). This pest has two genetic stains first one is rice stain hosted on grasses and rice**, and** corn stain is hosted majorly maize and minor sorghum, these both strains have been detected in Africa (Goergen *et al*, 2016). This pest was detected in India in May 2018 on the maize crop in Karnataka. (Saranabasappa *et al*, 2018). The study diversity of fall armyworm was studied in different states of India that indicated the distribution of rice stain of this pest. (HM swaymy *et al*, 2018) The corn stain of this pest was detected in sugarcane crops in Maharashtra (Chormule *et al*, 2019). It is the only pest that migrates across the whole world in a very short time and today's world now is a very serious pest of crops.

This paper describes the distribution and life cycle and damage along with new management and controlling operations against the fall armyworm. ~~and controlling operations against the fall~~ armyworm.

2. Distribution of fall armyworm:

Fall armyworm is distributed at a worldwide level and first time identified in Mexico and all of America (Johnson, 1986 and McGuire and Crandall, 1967). Adults of this pest migrate very fast~~ly~~ because of the movement of air and weather fronts (Sparks, 1979). In 2016, this pest was detected first time in West Africa and it spread very fast in sub-Saharan Africa and later it became a major pest in 44 African countries (Sagar *et al*, 2020~~; and~~ Sisay *et al*, 2019). According to a report by (Day *et al*, 2018), fall ~~armyworm~~ armyworms spread in Africa by ~~the~~ transportation ~~system~~ systems such as aircraft, ~~airplanes~~aeroplanes, and ships and by the wind. Later the first infestation ~~has been~~was identified in some states of India like Bihar, Chhattisgarh, Gujarat, Maharashtra Odisha, West Bengal, etc(CABI, 2020). This pest cause damage in many Asian countries like China, Japan, Bangladesh, Cambodia, Indonesia, Myanmar, Korea, Thailand, Sri Lanka, and Vietnam (FAO, 2019). This pest is recorded as short continents but it can cause huge damage and losses that's why this pest spread worldwide in a very short time. After that fall armyworms was identified in Nepal. The first infestation of this pest identified in the Nepal district was named, Namalparasi on the 9th of May 2019 (Bhusal and Bhattari, 2019) the declaration of this pest was made in the 19th

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meeting of the Nepal ~~plant protection organization~~Plant Protection Organization (NPPO) of Nepal (GoN, 2019).

3. Taxonomy of fall armyworm:

Fall armyworm has two strains that cause as high damage to the crop that stains are known as rice stain, maize stain**.** (Nagoshi *et al*, 2007). These stains are demonstrated based on primarily the observation that the stain (holotype) is asymmetrically distributed among plant hosts in the field with the maize that's why the first stain is known as the maize (corn) stain which represents the 80% larvae isolation from it. The second stain which is known as rice stain founded 95% larvae from the rice crop and Truff grasses. (Pashley, 1989: Prowell 1998 and Nagoshi *et al*, 2008). These stains are similar ~~at~~ in visualization but different on a molecular basis. Both strains of fall armyworm have been found in Africa and America (Jacobs *et al*, 2018). The given table is a simple way to understand the classification of fall ~~armyworm~~armyworms.

Table 1. Taxonomy nomenclature:

Kingdom	Animalia
Phylum	~~Arthopoda~~Arthropoda
Class	Insecta
Order	Lepidoptera
Family	Noctuidae
Genus	*Spodptera*
Species	*~~f~~frugiperda*

4. Economic importance of fall armyworm:

Larvae are the most devasting in nature that ~~deteriorates~~ deteriorate the quality of kernels and also ~~reduces~~ reduce the yield of the crop. This pest-infested young leaves, leaf whorls, tassel, and cob of maize. The presence of fall armyworms at the different parts of the plant depends on the growth and development of the plant (Gogrgen *et al*, 2016). For estimation of the damage caused by the fall armyworm, so we should have followed some variables and factors like as, the infestation of the pest depend on the total numbers of the pest population. ~~Time~~ The time of the pest infestation to the crops, environmental ~~condition~~ conditions and available natural ~~enemy~~ enemies of this pest at that time and main point is the overall health of the crop plant at that time the pest ~~stated~~ started the infestation (Bourdon *et al*, 2019 and Sagar *et al*, 2020). The management of this pest was unmanaged because of the inability of ~~the~~ natural control and proper identification, management of it at the starting of detection, and spreading of the fall armyworm (CABI, 2019). Fall armyworm can cause the maximum percent of the damage in maize or other crops. In a report of (Baudron *et al***,** 2019**)** he mentioned the entire percentage of the damage within the maize crop at that starting movement of this pest, in his work on the autumn armyworm he ~~calculate~~calculates the

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overall damage to the maize crop is26.4% and 55.9% and therefore the total loss within the yield of the maize crops is estimated there on time is 11.57%. After the bourdon, (Chimweta *et al,* 2019) published a report on the whole infestation of the maize and other crops and during this work, the full infestation caused by the autumn armyworm was 25% and 50%damage to the crop and therefore the reduction within the yield is58%. In Nicaragua, (Van Hui, 1981**)** found 33% of the incensement within the yield of the crop by applying the tactic of controlling this pest. At that point, the control was done by the chemical insecticide during the infestation during mid-to-late the whorl stage of the damage of the maize development is caused 15-73%when 55-100% of the plant was infested. This pest causes 3.2 million tone yield losses in Tanzania and 13.91 million tones losses in Uganda and 30.54 million tons in Ethiopia this data was taken from a report of (Kiprop, 2017). Fall armyworm caused high damage in Kenya, there's 250,000 ha of land is affected and within the total amount of the land, 11% of the land is fixed for the cultivation of maize cultivation. In Ghana and Zambia is additionally causing ~~the~~ high damage that's estimated ~~as~~ at 45%, and 40%. In Africa, fall ~~armyworm~~ armyworms cause damage in 8.5 to 21 million tonnes, and therefore the total worth of the number of maize is 250-630 million $dollars. In India, it causes severe damage on 170,000 ha of land in more~~ere~~ than~~e~~ ten states of India. In China, it caused damage in 11, 1992.17 ha land (Sagar *et al,* 2020).

5. Favorable conditions for fall armyworm:

Fall armyworms are affected by the changes in the climatic conditions that's may affect the total distribution of this pest in the various geographical regions. In a report of Ramirez-Cabial *et al,* 2017, it has been mentioned that the growth, abundance and survival rate, and mortality number of this pest are affected by the environmental conditions at a high level. "The overwintering process is influenced by the increased invasion of this pest."~~The overwintering process is governed by the greater invasion of this pest~~. It thrives in the cool, wet weather and severe outbreaks after the heavy rainfall conditions and humid weather also (Westbrook and Sparks, 1986). For the survival and the great season for its life cycle are the warm and humid growing season and rainfall. (Sagar *et al,* 2020) The development process of this pest may decrease in the winter season when the temperature goes below 10℃ (Assefa and Ayalew, 2019). For the efficient growth and development of this pest the tropical and subtropical areas are more favorable that's why in those areas it lives for more than 10 generations of its life cycle per year but in the temperate region, it passes only 2generation of its life cycle (Assefa and Ayalew, 2019). For the development of all stages of this pest, the temperature range is varied at different stages. The minimum temperature for the growth and development of this pest is 10℃ with the sandy – clay or clay sandy soils. For egg hatching, the temperature range varies from the 21-27℃ (Sagar *et al,* 2020) For the development of all larval instars, the temperature should be 28℃ whereas the pupation ~~required~~ requires a bit lower temperature to complete the life cycle of the fall armyworm. At 30℃ the wings of this pest deformed (CABI, 2019).

6. The life cycle of fall armyworm:

The life cycle of this pest completes in up to 30-90 days (30 days in summer, days in spring, and 80-90 days in winters) (Capinera, 2002). According to JL Capinera, 2002 this pest has up to 4 generations in its life cycle these generations are observed at different places like as in New York it shows a single generation, in Kansas, two-generation was reported and in South Carolina, three-generation was observed, and in Louisiana, the four generations of this pest have been founded.

Figure 11. Fall armyworm lifecycle.

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6.1. Eggs:

Eggs of fall armyworm are 0.4mm in diameter and 0.3 mm in height. The eggs are yellow to ceramic colour during the laying and after that, the eggs become brown before eclosion. (Rwomushana, 2019). Eggs of fall armyworm take 2-3 days to mature at 20-30□. Female lays eggs masses, approximately 100-200 eggs present in a mass (Prasanna *et al*, 2018). The eggs are covered with a covering layer referred to as scales which may be a felt-like layer of grey-pink colour scales that come from the feminine abdomen. ~~Female~~ Females lay eggs on the backside of the leaves the eggs are also laid on the stem of the plant of younger crops (CABI, 2018).

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Figure 22. Fall armyworm eggs

6.2. Larvae:

Larvae are a light green to dark brown colour with a longitudinal strip. During the 6th instar, this larva becomes 4.5cm long. The mature larvae have a white inverted "Y" shaped mark on the front of its epidermis that is a rough granular in texture (Prasanna *et al*, 2018). The larvae have eight prolegs and the final pair of the prolegs within the last abdominal segment (CABI, 2019). At the time of hatching these larvae are seen as green colour with black lines and spots on the upper body, as they grow either remain green colour or become buff-brown and have a black dorsal spiracle line (Sagar *et al*, 2020). The newly hatched larvae are burrowing in nature (CABI, 2017). According to Capinera, 2000 the 1-6insta larvae have a head capsule with different diameters like 0.35, 0.45, 0.75, 1.3, 2.0, 6.4, 10.0, 17.2 mm and the length of the full-body are about to 1.7, 3.5, 6.4, 10.0, 17.2, 34.2 mm respectively. At the sixth instar, the colour of larvae is nearly black and this phase is known armyworm phase. (Rwomushannma, 2019). The larvae of the autumn army contain 6 instars cycles but occasionally five.

Figure 33. Fall armyworm larva

6.3. Pupa:

pupa of the fall armyworm is shorter than larvae and that they are shiny brown and, the shape of the pupa is oval. (Rwomushana, 2019) and fall armyworm formed a cocoon of 20-30mm which are generally found in the 2-8cm depth of the soil(Sagar *et al*, 2020 and CABI, 2018). The size of the pupa is about 15mm in length found in the soil but sometimes found on the waste material of the crop when the soil is too hard to pupate (Silva *et al*, 2017).

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Figure 44. fall armyworm pupa

6.4. Adult:

According to CABI, 2019, physical body length is 1.6 cm and the wingspan 3.7 cm. The forewing is moulted with a discal cell containing straw colour on its three-quarters of the realm and fewer than one-quarter is dark brown with triangular white spots at the tip and near the centre of the wings, the male moths have shaded grey and brown forewings with the triangular white spots at the tip and near the centre of the wing. (Assef and Ayalew, 2019) this is absent in the female moths. Larvae of this pest are nocturnal and most active during warm, humid evenings (CABI, 2017 b) both adults of this pest can fly up to 100 km in a single night (Johnson, 1987). Length of the adult female is 1.7cm, and wingspan 3.8cm. The forewings of females are less distinctly marked, starting from a uniform fawn to a fine moulting of grey and brown colour (CABI, 2019). The hind wing of the females is like a straw colour with dark–brown margins. After 3-4 days of the pre-ovipostion period the female moth deposits, most of her eggs during the primary 4-5 days of its life. Some Oviposition occurs when the adult is about ~~to~~ 10 days with a correct range of 7-21 days (CABI, 2019).

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Figure 55. Fall armyworm adult female

Figure 66. Fall armyworm adult male

7. Damage symptoms of fall armyworm:

Symptoms of the fall armyworm infestation in maize or other crops started after the egg hatching process (Sagar *et al*, 2020). The skeletonising of a leaf is a typical symptom caused by the fall armyworm. the second instar larvae begin to make holes in leaves and eat from the edge of the leaves inward(Capinaera, 2002)Later on, the leaves of the plant ~~leafs~~ leaf ragged with round type appearance on the leaves that lead to becoming lose and detachment of the leaves from the plants. In severe infestation, extensive defoliation can be observed with the excessive fecal materials that are leftover on the plant. Eventually, due to excessive feeding on the plant, the reproductive part of the plant is affected very much and the development of the plant is stopped and initiation of silk and tassel in maize is also stopped (Reddy, 2019) The translucent and skeleton of leaves are observed at the first and second instar infestation while at the third to sixth instars there is larger holes are found in the crop plants. At the end of the fall, the armyworm looks like sawdust materials in the maize funnel or on the leaves (CABI, 2018b). Older larvae cause extreme level damage to the maize crop often leaving only the ribs and stalks of maize plants or ragged, torn appearance. According to the study of Marrenco *et al*, 1992 in the early stage fall armyworm damaged the vegetative growth of corn in Florida and they also reported the early whorl stage is the least sensitive stage to injury, and the mid-~~-~~whorl and intermediate, and late whorl stage was the most sensitive to injury. (Capinera, 2002).

8. Integrated management practices of fall armyworm:

Detection of the pest population of fall armyworm is of utmost importance before the pest causes economic damage to the crops. According to the research of Fernandez (2002), the control method should be applied to control the population of the fall armyworm when the 5%of seedling is cut or 20%whorl of the small plant, are infested by the fall armyworms. Generally, the first 30 days of the sowing of the maize and other crops is the best observation day of the infestation of fall armyworm. Assefa and ayalew, 2019, revealed in research that the larval stage of the fall armyworm is the effective stage for the proper management of the pest, and the timing to apply the control method is morning, afternoon, and evening. When all control methods are applied in an indispensable way. To control the population of this pest with the help of management tactics so there are many controls to control the population of the pest like as, physical control, mechanical control, cultural control biological control, botanical control, and chemical control.

8.1. Physical control:

In this control, handpicking of the pests is the very common method, and this method is reported by Firake, (2019), to control the pest population by ~~collection~~ collecting the control of larvae and destruction of the eggs masses, by immersed in kerosene oil, and water to control the population of fall armyworm. At the developing stage of the crop, we can use ~~the~~ sand, sawdust, and dirt to control the population by filling these materials into the whorls of the maize crops. Lime salt, oils, and soaps are also used to control of FAW (FAO, 2019). This method to control the population of the pest is done for the very small level and the small gardens.

8.2. Mechanical control: In this control, the pest population is controlled by the help of machines and also by mechanical forces like traps. 54% of the pest population is controlled by adaptation to the mechanical controlling method of the fall armyworm (Assefa, 2018). For the control action of the armyworm pest population, pheromone traps are used. In the one acre of land, only 5 pheromone traps are required to control the population of the fall armyworm (Firake, 2019). According to the FAO, 2017 report, a pheromone trap is used to attract the male moth that is highly recommended for the scaling as this method is simple to use. Another trap is used for controlling the pest population that known as bucket trap, this trap, a green canopy, yellow funnel, and the white bucket have been the major working parts to capture the population of moths of fall armyworms (Meaghaer, 2001 and Hardke *et al*,2015).

8.3. Cultural control: Ffall armyworm is often controlled through the use of chemical insecticides (Blanco *et al*, 2014) however, the application of ~~the~~ different cultural methods to control this pest infestation is controlled and also helps to minimize the crop losses by the fall armyworm In this control, intercropping is proved the best method to control this pest. In maize crops, we intercrop the legumes crops like red gram, black gram, green gram. The growing of these intercrops may prove to be an efficient method to control the population of fall armyworms. Likewise, if maize is grown in soil at a correct time and the fertilizer will be used appropriately and a hybrid variety of maize is also responsible for the reduction of the fall armyworm population. According to FAO, 2018 an efficient method to control this pest and that method is known as the "push-pull" method. In this method, a pest repellent plant grows with the main crops like as an intercropping and as a border crop. In the maize crops, the pest repellent ("push") plant (desmodium spp.) surround by a border with the pest attractive crop(pull") plant-like as Napier grass this method has been proved as an efficient way to control the population of the fall armyworm(Pradhan *et al*, 2019). According to a report that is an 82.7% reduction in the average number of larvae per plant and 86.2%plant damage per plot were observed in the climatic adaptation with the push-pull method in comparison

-To single crops (monocrop) of maize was sown that's along with the 2.7 times yield increment of the maize yield (Midega *et al*, 2018). Early crop planting is also an efficient way to control the fall armyworm; deep tillage and ploughing are used to control the pupae of the fall armyworm. In maize crops, we can also grow sunflower and beans as an intercrop because these crops are the non-host crops that are why fall armyworm could not be hosted on them (FAO, 2018). The crop sanitation process also helps in controlling the fall armyworm like as burning of the crop residue and the control of weeds. According to a report, 56% of the reduction in the fall armyworm population has been estimated by the cultural control method. This is a cost-effective method of pest management that's why every small farmer can be applied on his crops to control the incidence of fall armyworms (Assefa and Ayalew, 2018).

8.4. Biological control:

There are lots of bio-control agents are presented in this nature to control the fall armyworm (FAO, 2018). Techniques with increasing plant diversity by the intercropping of the beans crops and pulses crops and flowering crops plants are required to build the natural enemies of this pest (Firake, 2019 and Sagar *et al*, 2020). A dominant parasitoid often varies from one place to another place and for so many years (Luginbill, 1928 and Vickery, 1928). There are lots of predators and parasitoids and microbial controlling agents for controlling this pest are as follows (FAO, 2018 and Prasanna *et al*, 2018).

Table 2. ~~founded~~ Founded natural enemies of fall armyworm by ~~fao~~Fao.

Predators	~~Parashitoids~~Parasitoids	Microbial controlling agents
Earning sp.	Trichogramma parasitizing faw eggs	Fungal *Metarhizium anisopliae* *Metarhizium rileyi* *Beauveria bassiana*
Lady beetle sp.	W~~w~~inthemia trinitatis	Bacterial Bacillus thuringiensis
Tachinid fly	Campolestris flavicincta	Viruses Spodoptera frugiperda multicapsid nucleopolyhedrovirus(sfMNPV)
Asian and flower bugs	Chelonus spp.	
Ants, Predaceous bugs	Telenomus spp.	
Birds and bats Ground beetles		

By the microbial control of the fall armyworms there are required to the B~~b~~acillus thuringiensis var kurstaki formulation @2g/litre and for the efficient control of the fall armyworm 400g/acre powder of the B.thuringiensis. Metarhizium anisopliae is also used for the control of this pest and required to the metarhizium anisopliate talc formulation (1×108cfu/g)@5g/liter of water spray on the whorls after the 15-20days after the sowing. Similarly, 1-2 spray gives the best result on the control of fall armyworm at the different stages of the damage. According to the report of FAO (2018), a biopesticide that is especially based on the bacillus thruingiensis and fungus and baculo-virus has been an effectively controlling efficiency to control the fall armyworm. These all types of biocontrolling agents reduced the defoliation of leaves and also help to control the damage(Molina- Ochoa *et al*, 2003) and successfully reported that these bio control agents help to control fall armyworm (Pilkington *et al*, 2010). As per the report, there are mainly 53spices of parasites are found at the global level that represented the three genera and 10 families which are most effective to control the fall armyworm (Ashley, 1979, sparks, 1986, Assefa, 2018). The report of Aktuse et al. (2019) mentioned the efficacy of entomo- pathogenic fungi against eggs and second instar larvae revealed that 30%of morality of second instar larvae by the Beauveria isolated whereas metarhizium isolate provided the 87% and 95.6% of eggs and neonate larvae

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mortality respectively. In this control, we need to properly identify and study all predators and parasitoids which use for the control of pests of the lepidopteron order and Noctuidae family.

8.5. Botanical control:

In this control, the use of plant-derived pesticides for the controlling of this pest. There are a lot of methods to control the fall armyworm in this world through local botanical extract, soil, sand, wood ash, lime, oils, and soaps (Sagar *et al*, 2020). According to the report of Souza et al. (2010) plants can control the population of pests and mentioned some plant species that show the controlling ability against the fall armyworms. Corymbia citridora, Eucalyptus urograndis also show the property to control the fall armyworm population. Neem seed powder has been also reported to be effective in the killing of fall armyworm larvae and in a laboratory it killed up to 70% of the larvae population (Njuguna *et al*, 2021). According to a report of Figueroa-Brito *et al*, 2013, Carica papaya seed proves to be more efficient compare to Malathion chemical to control the population of this pest. Similarly, some plant oils obtained from cloves, turmeric, palmarosa, and neem have significant effects in the controlling of the first and second instar larvae of fall armyworm. Many plants in his report that show the killing properties of the fall armyworms and that plants are like as, Azadirachta indicia, Millettia ferruginea, croton macrostachyus, phytolacca docendra, jatropha curcas, Nicotiana tabacum, and chrysanthemum cineraiifolium. Moringa plant extract and Cymbopogon citrtus, Malva sylvestris, Ruta graveolens, Petiveria alliacea, zingiber officinale, Baccharis Cymbopogon citatus, also shows the ability to kill the larvae of fall armyworm, in a very efficient way. This control method is too simple to control the pest in a very simple way because the raw material of this control is present in huge amounts in a natural and this method will become a very easy method for the African peoples. After all, this method is used at a small level by the small farmer and it will become a simple method to control the population of the fall armyworm at a very low cost of the input (FAO, 2018). At the current time, there are lots of methods that are based on bio-controlling (plant-based materials) ability to control the pest population.

8.5.1 Cow urine Bio-insecticides :

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~~8.5.1.~~ ~~Cow urine bio-insecticide:~~

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In this innovative world, there are lots of organic methods and domestic methods used to control the incident of pests. These methods became the most useful and trustful method to control any pest population because it cannot deteriorate the quality of the atmosphere and another factor in the series of organic ~~chemical~~ chemicals The first chemical is formed with the help of various components, which are as follows. ~~the first chemical is formed by the help of different different thing that things are as follow~~.

Table 3. Ingredients of cow urine bio-insecticide

Ingredient	Dose
1 Pot (iron, plastic, and copper, cemented)	-
Cow urine	10 litre
Dhatura	2-3 kg
Neem leaves	2 kg
Green chillies	250 gm
Argemone mexicana(satayanashi)	1-2 kg
Garlic	500 gm
Onion	500 gm

First of all, in a pot mix all these materials and crush them and mix it and leave them for three days. After the three days, this mixture will be preserved for application in infected field basic requirement of this mixture is a 1-liter mixture ~~dissolve~~ dissolved in 25 liters of water and spray on the crop to control pests (mainly worm and moth) and another attacker spry timing for better result spray done on 7 am to 9 am morning and 3 pm to 6 pm evening.

~~8.5.2.~~ 8.5.2 Dash Varaniyan insect controller solution :

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This is a major organic insecticide used to control the pest population for the formation of this mixture we have to use this material for the formation of 1000 litre organic insecticide.

Table 4. Ingredients of dash varaniyan insect controller solution

Ingredient	Doses
Neem ~~leafs~~leaves	3kg
Pumpkin ~~leafs~~leaves	3kg
Aakuan leafs	3kg
Dhatura leafs	3kg
Beshram leafs	3kg
Uklyptics leafs	3kg
Wild Tulsi leafs	3kg
Banyan leafs/ peepal leafs/ Asoka leafs	3kg
Arandi leafs	3kg
Ghaner leafs	3kg
Cow urine	800 litre
Ammonium chloride	250 gm
Jaggery	3 kg

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Mix all the material in a 1000 litre capacity tank and leave for 8 days but every day's rotation of this mixture is mandatory in the same direction after the formation the bio insecticide farmer should have spray 1liter of this mixture in 10 liters of water every Amavasya night.

The spray should apply on the field every 15 days of intervals the population of pest will control.

8.6 Chemical control:

When the population of fall armyworm crossed the economic threshold level and for the instant control of the pest ~~infestation~~infestation, we use a different type of chemical to control it. The appropriate time for the chemical application is of utmost importance for the management of fall armyworms. An individual should have proper knowledge of the life cycle of this pest and accurate timing for the application of pesticide for example if there is no effectiveness in spring of chemical when the larva invaded deeply in maize whorls and the chemical sprayed in a day time so the result will be no more beneficial to the crop because this pest is Noctunal in nature that means it comes out from whorls for feeding in the night for feeding on the crop (Day *et al*, 2017). For the control, there is a huge amount of chemicals developed and their names are, *Methomyl 20%EC, Pytrthoids, Cyfluthrin 5% EW, Organophosphate chemical groups, Methyl parathion 50% EC, Chlorpyrifos 48% EC, Carbosulfan 25%EC, Emamectin benzoate 5%SG, cartap hydrochyroride 50%Sp, chlorantraniliprole 18.5SC, fluebendamide 20%WG, spinetoram 11.7%SC.* These given chemicals are generally used for managing and controlling the population of fall armyworm Trash *et al,* 2013 mention above these chemicals used to control the population by the different methods like as foliar spry and sawdust application against *Spodptera furgiperda***.** A scientist named Van Huis (1981) mentioned carbofuran and chlorpyrifos used as a mix with sawdust chemical used against for control the Damage of fall armyworm. With the help of this chemical 20% of control on the population of fall, armyworm was recorded. According to Crus and Bhusal and Bhattarari, 2019 90% of larva mortality through the use of spinosad and new insecticides *chlorantraniliprole, flubendiamide,* and spinetoram was founded to perform a better result compared than traditional insecticides like *lambda-cyhalothrin and novaluron*.

9. A possible method to control fall armyworm in Bareilly and Rampur:

We know that the fall armyworm is the most devasting pest for the maize and sorghum crops, but in the Bareilly and Rampur region, the maize and sorghum crops are not cultivated as major crops. In these districts, this pest causes damage in wheat crops instead of maize of sorghum and another crop at the stage of booting and heading. In this location, this pest cannot cause very severe damage to the crops so the management of this pest will be very easy in the two districts. For the management of this pest, the farmer goes on the cultural method like as deep ploughing, trap cropping, sowing time adjust, selection of variety and the farmers also install some pheromone and bucket trap to control the incidence of this pest and by the chemical control an individual can control the population of pest by the spraying of very common insecticide like lambda-cyhalothrin and another chemical which will be available on the market. For organic control, the farmer can also use the organic method to control this pest and the biological methods are:

9.1. Use of buttermilk:

We can use buttermilk to control all categories of caterpillars so for the formation of buttermilk mixture we need this material first one is buttermilk 500ml-1liter and water 100liter and jaggery. All the material mix in a pot for the formation of this mixture but there is the main condition the buttermilk should be old 20 to 25 days after three days of preservation we can use this mixture to control the pest population.

9.2. -Varaniyan insect controller soulution:

It is soulution of 10 different types of plant leafs that are use to controll the population of the pest. This is a common mixture that are generally use for control of all types of larvaes of all families and order. The process and its using time are given above in the botanical control and its ingredient mentioned in the table 4.

9.3. Cow urine bio-insecticide:

This is a very cost effective method to control the pest population without causing a single percent of harm to human beings and nature. This bio-insecticide formed by the different types of ingredient that are mentioned above in the table 3. During the application of ~~these~~ these type of solution the farmer has to irrigate his crop before the application of these solutions.

In the formation of these, there is no use of high input cost and by these methods, no serious problems will be faced like insecticide residue, natural enemies, death, and pollution, and others.

10. Conclusion:

The fall armyworm (*Spodoptera frugiperda)* has been reported as the most devasting pest across the world. This pest can spread very fast all over the world causing a large amount of reduction in agricultural production. This pest has a very fast developing and spreading nature that's why in a very short time this pest will become a major pest in the whole world. For the control of this pest, the integrated management practice should be applied at the starting of the infestation if the managemental operation will apply after a mid-time of infestation so this pest will cause high damage to the crop and there is no mean of the all managemental operation for controlling the fall armyworm. For the identification and application of the controlling methods, there are the main body is established that known as the advisory community to manage the fall armyworms. In this community, they teach the farmer and give an idea about the identification and life cycle and damage and damage strategies of this pest and how to control the losses in the agricultural production caused by the fall armyworms. Locally these all methods played a vital role in the controlling of this pest for the smallholder farmers' against the management of the fall armyworm.

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